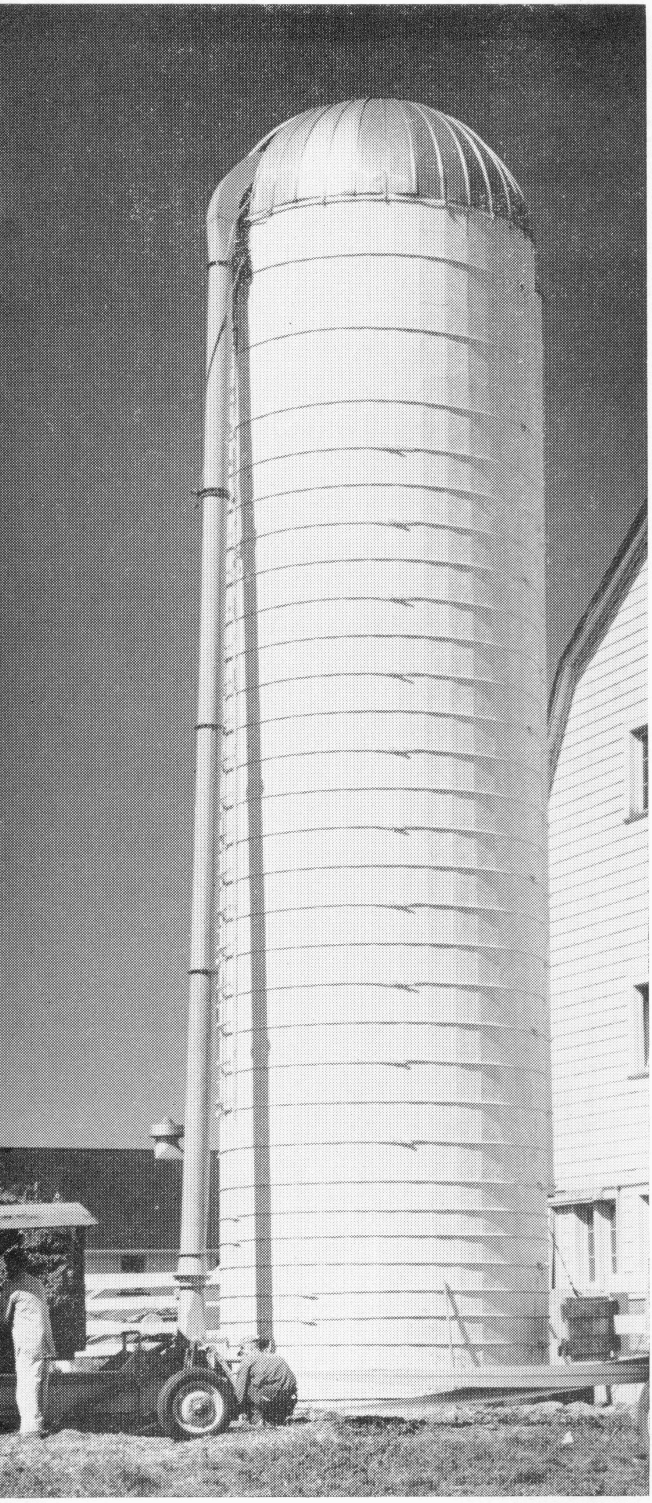

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COSTS OF STORING Grass-Legume SILAGE

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OHIO AGRICULTURAL EXPERIMENT STATION

WOOSTER OHIO

CONTENTS

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On the Cover:

Low annual storage costs were experienced in large, upright silos.

COSTS OF STORING GRASS-LEGUME SILAGE

E. T. SHAUDYS, J. H. SITTERLEY and J. A. STUDEBAKER

SUMMARY AND CONCLUSIONS

Grass-legume silage use has rapidly increased on Ohio farms during the last decade. Three basic types of silos: upright, bunker and trench were found in use. Information was obtained on 149 silos by survey interview with 104 farmers. Depending on the availability of meadow crops, labor, capital and availabilities of forages, a particular type of silo may be advantageous for a certain farm.

Both investment and annual storage costs were important to farmers in deciding which type of silo to build. Investment costs per ton of capacity were highest for upright silos and lowest for trenches. Economies were realized in all types with large capacity silos. Low capital requirements were an advantage of horizontal silos for many farmers.

Small upright silo owners, 100 tons and under, experienced higher annual storage costs per ton than either bunker or trench users. Large upright silos, 300 tons and over, had slightly lower annual cost per ton than bunker or trenches. Spoilage losses for grass silage were valued at about $7.25 per ton. This was the cost per ton of producing, harvesting and filling silos with grass-legume silage.

Spoilage could be valued at the out-of-pocket filling costs on farms where factors other than forage limit livestock numbers. Cost of spoilage losses may be extremely high on farms where livestock numbers are limited by forage supplies. This cost might be the net return realized from the additional livestock that could be carried if spoilage had not occurred. Spoilage losses can be reduced by using low cost plastic sheeting for establishing a seal and preventing weathering. Corn silage spoilage losses would generally have higher values than grass-legume silage.

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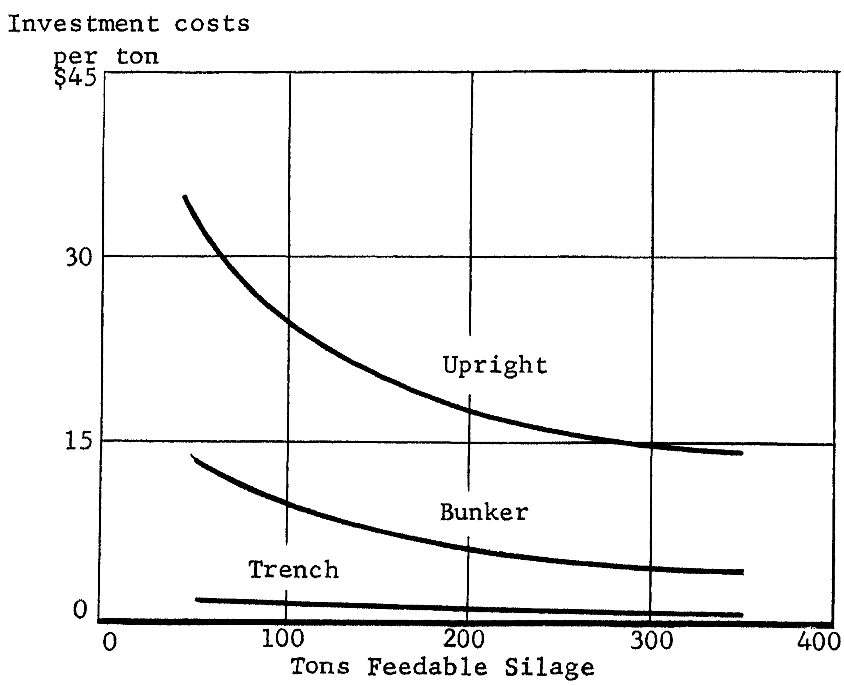
[1]This publication is one of a series to provide information needed in selection of forage harvesting, storage and feeding methods. See Shaudys, E. T. and Sitterley, J. H., "Labor and Equipment for Feeding Silage", OAES Research Bulletin 820, November, 1958, Wooster.

Total spoilage losses tended to increase in proportion to capacity of bunker and trench silos. Small increases in spoilage losses were experienced with larger capacity upright silos. Spoilage loss was primarily a function of the exposed surface area. The average spoilage loss per ton of feedable silage was $0.31 per ton for upright silos, $0.89 per ton for trench silos, $1.07 per ton for bunker silos and $1.59 per ton for stack silos.

Investment costs per ton were lower in larger capacity upright and horizontal silos. Considering investment and spoilage loss costs, large bunker and trench silos had slightly higher annual storage costs than large upright silos.

The following factors were considered important in the selection of a silo structure:

Low investment costs of horizontal silos were attractive to many farm operators.



Source: Appendix, Table 1.

Chart 1.—Investment costs by tonnage of feedable silage for upright, bunker an trench silos, Ohio, 1956.

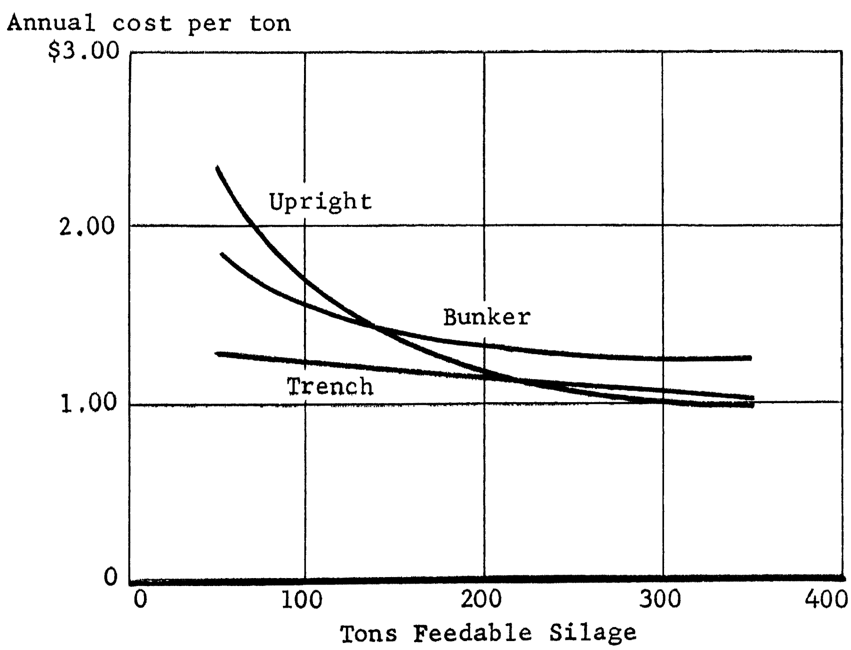
Low spoilage losses favor upright silos.

Spoilage is the largest annual cost in horizontal silos. USDA investigators reduced spoilage losses in horizontals comparable to uprights with the use of low cost plastic sheeting.

Both beef and dairy cattle were satisfactorily fed from all types of silos studied.

Esthetic values favor upright silos. The tall structure enhances pride. Horizontals seldom have an impressive or neat appearance.

Farm or local labor was used in the construction of horizontal silos providing an opportunity for reducing out-of-pocket investment expenditures. Uprights were erected by the manufacturers or dealers.



Source Appendix, Table 1.

Chart 2.—Annual costs by tonnage of feedable silage for upright, bunker and trench silos, Ohio, 1956.

A solid floor and approaches were necessary for satisfactory horizontal silo use. Some farmers had attempted to use trenches and bunkers without good floors and reported mud and contamination difficulties.

Self-feeding at a low cost was being done in several horizontal silos. Large investment in equipment is necessary for automatic or self-feeding from uprights.

Optimum location of the silo structures is often more difficult to obtain with horizontals than upright silos.

INTRODUCTION

Forages have been preserved as silage since 1875 in the United States. Widespread feeding of silage did not take place until the advent of the corn binder during the 1890's. Corn was and is still the most important silage crop. Heavy labor requirements and the high cost of

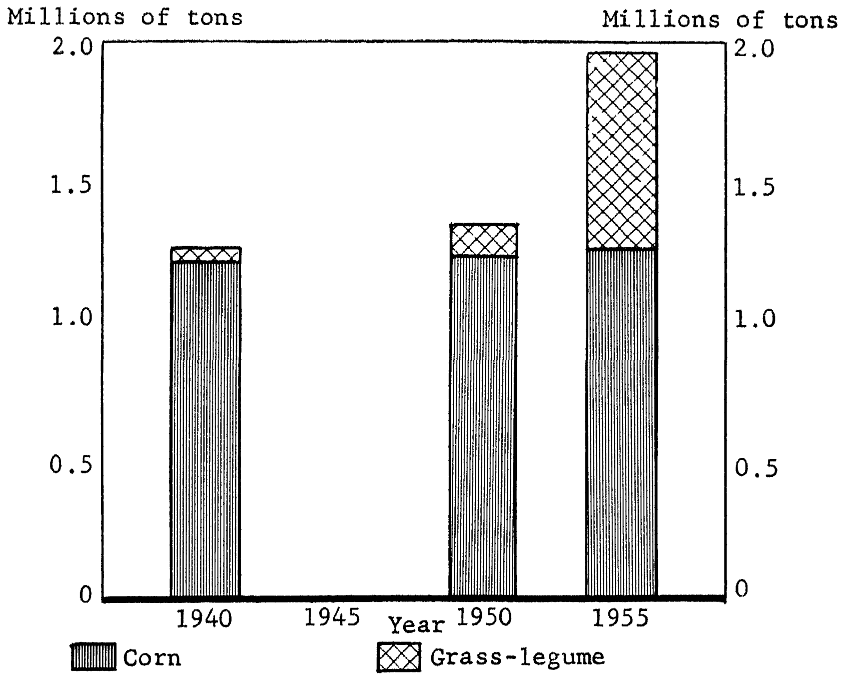


Chart 3.—Tons of corn and grass-legume silage made in Ohio, selected years.

making grass-legume silage with a hay loader and stationary ensilage cutter retarded its acceptance. Development of the field forage harvester greatly reduced the physical effort and improved the efficiency of handling meadow crops for silage. Opportunity to reduce weather damage and the availability of surplus forages early in the season contribute to the increasing use of meadow crop silage.

Silage storage capacity in Ohio increased 2/3 of a million tons between 1940 and 1950. Approximately 1 1/3 million tons of corn silage have been preserved and fed annually for the past 35 years. Tonnages of grass-legume silage fed in Ohio increased 8 fold during the 5 years, 1950-1955. During 1955 practically all of the 2/3 million tons of increased storage capacity was used for grass-legume silage.

OBJECTIVES

Many factors need consideration when deciding how to most efficiently handle the forage crops. Some farmers have based their decisions primarily on harvest costs. Harvesting is a vital cost but storage, spoilage losses and feeding costs are important. Two methods are available for the preservation of the meadow crops—hay and silage. Silage can be stored in upright, trench, bunker, stack and temporary silos.

The purpose of this study was to obtain information on farmers' cost of installing and using different types and sizes of silo structures.

HOW THE STUDY WAS MADE

Data were collected on 149 silos by survey interviews with 104 farmers in 17 counties. Construction cost, materials used, expected life, erection methods, repairs, capacity and spoilage losses were obtained for 67 upright, 32 bunker, 34 trench, 7 temporary and 9 stack silos during 1956. Yields, meadow mixtures, equipment used, method of filling, farmers' experiences and harvesting practices were also secured.

Before cost comparisons can be made, a careful determination of capacity for different types of silos is essential. Forty pounds per cubic foot has been accepted and widely used as the density for all types of silos. Eckels, Reed and Fitch reported this density for corn silage in upright silos after settling.[2] Shepherd and Woodward reported a greater density (48.5 pounds for 35 feet of settled silage).[3]

[2]Eckles, E. H., Reed, O. E., Fitch, J. B., Kansas Agricultural Experiment Station Bulletin 222, 1919.

[3]Shepherd, J. B. and Woodward, T. E., USDA Circular 603, 1941.

Several variables affect silage density such as: fineness of cut, moisture, compression, packing and maturity of crop ensiled. Shepherd and Woodward measured density with corn cut at ¼ to ½ inches before kernels were fully dented and with 70-74 percent moisture.

When the capacity of upright and horizontal silos included in this study were compared on a 40 pound per cubic foot density, a great difference in meadow crop yields appeared to have been obtained. Yields amounted to 4.6 tons per acre on farms with upright silos and 6.3 tons on farms with horizontal silos. Both groups of farmers reported similar yields of field cured hay. Believing a difference existed in densities, core samples were weighed from 7 horizontal silos. These averaged 30 pounds per cubic foot which compared favorably with Shepherd and Woodward for the upper 5 feet in upright silos.[4]

A trench silo located on the Ohio State University Hess Farm was filled with corn silage and was weighed out as fed. This trench was 7 feet, 8 inches deep and had an average density of 35.8 pounds per cubic foot. The average weight of silage in the upper 5 feet was 31.3 pounds per cubic foot.[5]

When density in horizontal silos was computed on the basis of 30 pounds per cubic foot, the estimated yield realized was 4.7 tons per acre as compared to 4.6 tons on farms using uprights. For this study 30 pounds per cubic foot has been used as the average density of horizontal silos and 40 pounds per cubic foot for upright silos.

UPRIGHT SILOS

CAPACITY

Three capacities can be obtained for an upright silo. Capacity, as used in this study, needs clarification before construction and annual storage costs are considered.

1. **Manufacturers capacity**, although frequently used, is misleading. This estimate is based on the silo being filled under ideal conditions to its maximum volume, (i.e., a 40-foot silo contains 40 feet of settled silage).

2. **Settled capacity** is another method expressing silo size. With modern harvesting and filling equipment, most upright silos can be filled in one day with a refill the next. Fineness of cut, moisture, rate of fill, maturity and type of forage influence the amount of settling.

[4] Ibid., Shepherd and Woodward.

[5] Rath, H. J., "A Study of the Trench Silo", unpublished Masters Thesis, Ohio State University, 1934.

After one refill, a 40-foot silo usually settles about 2 doors or 6 feet. Upright silos were assumed to have a "settled capacity" of 85 percent of the silo height for this study.[6]

3. **Feedable silage capacity** was determined as the quantity after settling had occurred and spoilage was removed. Spoilage losses reduce the quantity of feedable silage as well as quality. Number of spreader or trailer loads removed and the inches of silage thrown out were used to compute tons of spoilage loss. Feedable silage was used as the measure of capacity for this study (Appendix, Table II).

Upright silos erected during the past 5 years were either concrete stave or metal. More than half, 36, of the 67 silos studied were of concrete stave construction, and 14 were metal; the remainder were wood, tile or concrete block. The concrete stave silos were typically 12 × 40's with a total capacity of 89 tons and a settled capacity of 75 tons with a 3 ton spoilage loss leaving 72 tons of feedable silage. The feedable capacity of the concrete stave silos ranged from 37 to 157 tons. Metal silos were typically smaller, 12 × 30's, and had a settled capacity of 61 tons with 58 tons of feedable silage ranging from 35 to 100 tons (Appendix, Table III).

INVESTMENT COSTS

Usually upright silos were purchased as a package and erected by the dealer or manufacturer.

Foundation, staves or wall, ladder, chutes, roof and the labor for erection were included in determining the silo construction cost. Farmers also reported the labor they contributed toward the erection of the silo. Costs were standardized at 1955 prices.

[6]Shepherd and Woodward reported 17 percent settling.

TABLE 1.—Construction Costs by Type, 67 Upright Silos, Ohio, 1956

Type	Number	Tons feedable silage	Number with roof	Investment cost 1955	Cost per ton
Concrete stave	36	72	19	$1737	$24.12
Metal	14	58	11	1159	19.98
Wood	9	63	3	556	8.83
Other*	8	75	3	1140	15.20

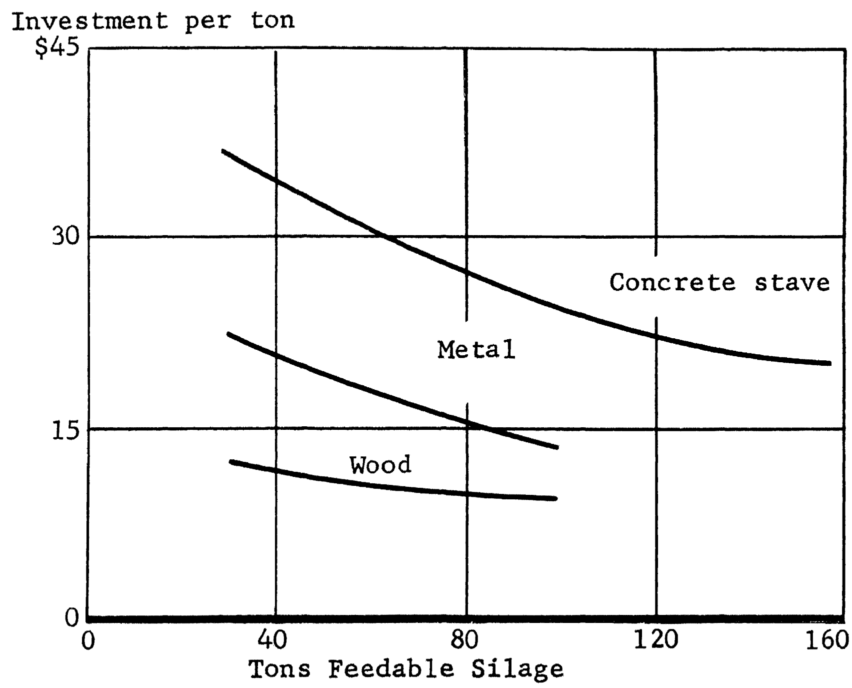
*Four tile, four concrete block.

The silo size and materials affect the cost. Despite the difference in total and per ton costs, more farmers purchased concrete stave silos than any other type.

Metal and wood silos were smaller in capacity than concrete stave and had lower investment costs. The nine wood silos were very low in both total and per ton cost, however, all of these had been in use several years. None of the wooden silos were erected during the last five years. Tile and concrete block silos had been erected several years ago.

More than one-half of the concrete stave, four-fifths of the metal and one-third of the wood silos had a roof. Most farmers reported a silo roof offered no major advantage other than worker convenience and insurability.

Investment economies were realized with larger capacity silos. A concrete stave silo with a capacity of 40 tons feedable silage had an investment cost of \$31 per ton. The same type silo had an investment cost of \$20 per ton with 100 tons capacity and \$18 per ton with 160 tons capacity. Similar economics resulted with increases in size in other types of silos.



NOTE: 36 concrete stave $yc = 44.91475 - .27502\,X + 00080X^2$
14 metal $yc = 27.19220 - .13898\,X + .00005X^2$
9 wood $yc = 13.75800 - .05047\,X + .00007X^2$

Chart 4.—Investment costs by type and size of upright silos, Ohio, 1956.

ANNUAL COSTS

A silo provides the means of preserving a feed harvested during one season for use during another. Any increase in value of the preserved forage after harvest was because of a difference in the time the forage was available for feed, not an increase in nutrient content.

Annual silage storage costs included: depreciation on the silo, repairs, interest, taxes, insurance and spoilage. Fermentation and intangible losses were beyond the scope of this study. All losses were relative to the volume of silage. Depreciation was computed on the 1955 investment cost divided by the life as reported by each farmer. Tile and concrete block silos were reported to have the longest expected life, 45 years, and with proper maintenance were considered indestructible. Mortar joints needed periodic repointing and careless use shortened silo life if blocks or tiles were chipped or broken. Concrete stave silos were reported to have a 40-year expected life followed by metal and wood silos with a 30-year life.

TABLE 2.—Annual Storage Costs by Type, 67 Upright Silos, Ohio, 1956 (Average Feedable Capacity)

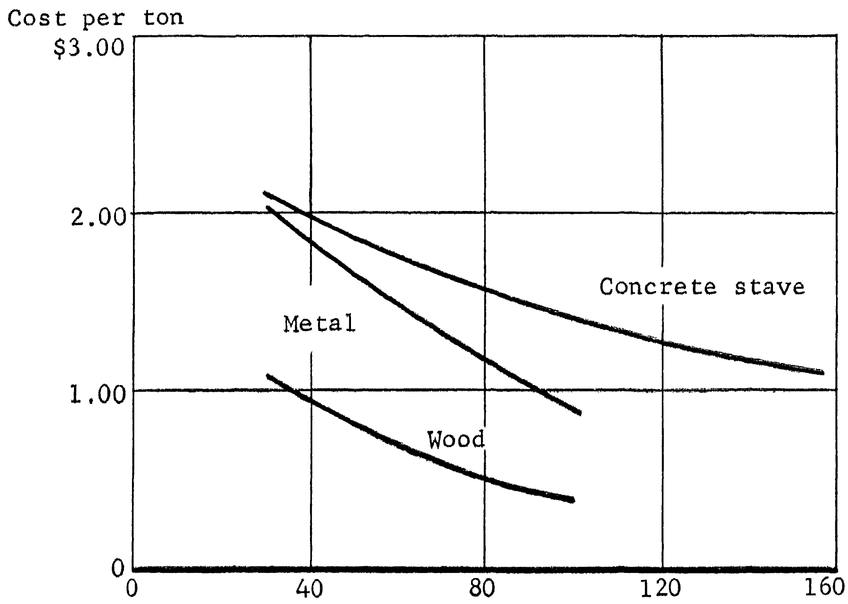
Items	Type			
	Concrete stave	Metal	Wood	Other*
Number	36	14	9	8
Investment	$1737	$1159	$556	$1140
Years of life	40	30	31	45
Annual costs				
Depreciation	$ 43.51	$ 38.09	$ 17.88	$ 25.12
Repair	5.54	14.96	5.67	12.44
Interest, tax, insurance	55.41	37.33	18.16	36.68
Spoilage	21.87	20.01	17.80	22.67
Total	$ 126.33	$ 110.39	$ 59.51	$ 96.91
Tons feedable silage	72	58	63	75
Annual cost per ton	$ 1.75	$ 1.90	$ .94	$ 1.29

*Four tile, four concrete block.

Concrete stave silos had an annual cost of $1.75 per ton which was lower than for metal but higher than wood, concrete block or tile. Taxes were charged at 20 mills on 40 percent of mid-life value, insurance at $4.00 per $1,000 on 80 percent of original cost and interest at 5 percent of mid-value. Actual reported repair costs were used. Spoilage charges were based on the cost of producing, harvesting and storing forage. This was computed to be $7.33 per ton for upright silos. Spoilage reported was approximately the same thickness in all types of upright silos.

Larger silos had a lower annual use cost per ton than smaller ones of the same type. Fixed costs and spoilage losses were spread over more tons in large silos, reducing the cost per ton.

Concrete stave upright silos were found to have the highest annual storage cost per ton. Wood silos had the lowest annual cost. However, farmers preferred metal and concrete stave silos over wood. Metal silos had a lower annual cost than the concrete stave silo and a shorter life.



NOTE: 36 concrete stave yc=2.65156 − .01753 X +.00005X²
14 metal yc=2.85220 − .02370 X + 00004X²
9 wood yc=1.95650 − .02965 X +.00014X²

Chart 5.—Annual storage costs by type and size of upright silos, Ohio, 1956.

HORIZONTAL SILOS

Horizontal silos are a relatively recent innovation for the storage and preservation of silage in the United States. Pit silos have been used in some parts of the world for many years. Silage stored in pits must be hoisted up and transferred to a wagon and transported to the feeding area.

Trench silos are a modified form of a pit. A rectangular trench is excavated below the ground surface in a well drained location. Trench silos can be made for the cost of removing the earth. Many farmers reported dissatisfaction with unimproved trenches because of spoilage loss and mud caused difficulty in removing silage. Trench silos work well when properly drained, lined and provided with a solid floor and approaches.

Bunker or above ground horizontal silos were another type studied. Many farms do not have a desirable site for trench silo construction. Bunkers are rectangular in shape but with the walls built above the ground surface. Development of bunkers enabled farmers on level farms to use horizontal silos. A bunker silo with concrete floor and wood sides offers: low construction cost, ease of filling, removal and feeding advantages under numerous farm situations.

CAPACITY

Feedable capacity of horizontal silos was determined after spoilage had been deducted from the settled silage. Volume of settled silage was computed by multiplying the mean width times the height of silage times length minus twice the height (cubic feet of volume $= h \times w \times l - 2h$). Silo length had to be reduced by twice the height because the ends were usually tapered with a 2:1 slope. Tapering was necessary for pulling wagons into the silo for unloading when filling. The settled volume less the spoilage reported by farmers was converted to tons of feedable silage at 30 pounds per cubic foot.

SPOILAGE

Spoilage costs were based on production, harvest and storage of the forage. This was valued at $7.22 per ton in horizontal silos. Spoilage was a large and important item of cost. Between 13 and 17 percent or about 1/6 of the harvested forage was lost. A large surface area is exposed to the elements causing deterioration and permitting loss of nutrients. Many farmers need all of the forage they can produce to support the number of livestock necessary for an adequate volume of business. The large spoilage loss has caused some farmers to reject the horizontal silo as a practical structure for their use.

Numerous devices had been used by farmers to reduce spoilage losses. A variety of coverings such as earth, sawdust, lime, fertilizer sacks, sisalcraft paper and plastics have been used. In general, the farmers felt that the silage saved was about offset by the cost of covering. A good job of filling and particularly topping off, was more effective in reducing spoilage than many covering materials used.

Gordon and McCalmont, Bureau of Dairy Industry, USDA, found that with proper use of modern plastics, spoilage losses can be reduced as low as achieved in upright silos.[7] Wide plastic sheeting weighted down with sawdust and railroad ties was used for making the seal and eight pounds of sodium meta-bisulphite per ton were used as a conditioner. Cost of six millimeter polyethylene is low enough to make this covering practical. Sheeting can be obtained up to 32 feet in width and 100 feet in length for about $90 per sheet. Earlier, when only narrower widths were available, seams were lapped or taped. During weathering these seams frequently opened admitting air, permitting oxidation, and spoilage resulted.

These results were obtained under ideal conditions. Favorable results in reducing spoilage have been realized with care and good management under farm conditions.

BUNKER SILOS

Bunker silos were above ground rectangular structures with two supporting side walls and usually an improved floor. A convenient well drained location was essential for satisfactory operation. Usually bunkers were constructed with local or farm labor.

A variety of materials was used for the construction of the 32 bunkers studied. Wood sides were used for 25 silos, concrete block for 6, and one silo had one side of wood, the other was an earth dike. Concrete floors were used in 24 silos, gravel in 6, blacktop in one and earth in one.

INVESTMENT COSTS

Costs were directly related to construction materials. Silos with gravel floors and noncreosoted wooden sides had low construction cost. Several of these silos were built with home-grown or used lumber. Farm labor was the largest construction cost. Frequently a short life and large spoilage losses were experienced. Silos with concrete floors,

[7]Gordon and McCalmont, "Agricultural Research", February, 1958, Agricultural Research Service, USDA, Washington 25, D. C.

pressure creosoted posts and tongue and grooved or ship lap plank siding had a higher cost per ton of capacity but a longer life and more satisfactory operation. Farmers reported that they favored these materials and most of the newer silos were constructed with them. Concrete floor, concrete block side silos had been built earlier but had about one-half the capacity with a one-third higher cost per ton.

The typical bunker silo was 6 feet high, 24 feet wide and 60 feet long with a capacity of 93 tons of feedable silage.

Investment cost per ton of feedable silage varied from about $9 for a silo of 88 tons to $6 for a silo of 265 tons with a concrete floor and creosoted wooden sides (Table IV, Appendix). Similar variations in costs existed for silos of other materials.

Concrete floors had the highest cost per square foot of areas averaging 26 cents. Concrete was laid about 5 inches thick and cost $14 to $15 per cubic yard when near a cement plant. The 6 silos with gravel floors had a cost of 6 cents per square foot and the blacktop, 14 cents per square foot.

This is a bunker silo. They are constructed above the ground with two supporting side walls and generally have an improved floor. A well drained location is essential.

TABLE 3.—Investment Cost of Bunker Silos with Concrete Floors and Creosoted Wood Sides by Three Sizes, Ohio, 1956

Items	Size		
	Small	Medium	Large
Height (feet)	6	6	6
Width (feet)	15	20	30
Length (feet)	69	101	101
Floor (sq. ft.)	1035	2020	3030
Sides (sq. ft.)	828	1212	1212
Cost*			
Floor	$ 269	$ 525	$ 788
Sides	505	739	739
Total	$ 774	$1264	$1527
Tons of feedable silage	85	170	255
Cost per ton feedable silage†	$ 9.10	$ 7 44	$ 5.99

*Includes hired and farm labor.
†Fifteen percent loss.

Some reduction in cost per square foot was experienced in the larger silos.

Wood sides used in 25 silos had an average cost of 61 cents per square foot, however, some did not have pressure creosoted wood. The 17 bunker silos with creosoted wood sides had an average square foot side cost of 83 cents. Concrete block sides were slightly higher than creosoted wood.

TABLE 4.—Investment Costs by Type, 32 Bunker Silos, Ohio, 1956

Material	Number	Tons of feedable silage	Cost			Cost per ton
			Floor	Sides	Total	
Concrete floor, wood sides	17	151	$485	$793	$1278	$ 8.46
Concrete floor, concrete block sides	6	81	296	700	996	12.30
Gravel floor, wood sides	6	86	67	49	116	1.35
Other*	3	232	356	467	823	3.54

*One earth floor, wood side; one blacktop floor, wood side; one concrete floor and one wood, one earth side.

Material and size greatly affected the cost per ton of the storage structure. The 6 concrete floor, concrete block side silos had the highest cost per ton of any but were the smallest silos with an average of 81 tons of feedable silage. The 17 concrete floor, wood side silos had almost twice the capacity, 151 tons of feedable silage with about two-thirds the cost per ton. Other types of silos reported a lower cost per ton but were made of materials available at no or little cost to the farmer and did not always prove satisfactory.

TABLE 5.—Annual Storage Cost by Type, 32 Bunker Silos, Ohio, 1956 (Average Feedable Capacity)

Item	Type			
	Concrete floor, creosoted wood sides	Concrete floor, concrete block sides	Gravel floor, wood sides	Other*
Number	17	6	6	3
Investment	$1278	$996	$116	$822
Years of life	38	47	20	28
Annual costs				
Depreciation	$ 33.63	$ 21.19	$ 5.85	$ 29.36
Repairs	6.71	7.30	12.33	4.70
Interest, taxes	37.06	28.08	3.27	23.18
Spoilage	161.29	119.48	124.87	337.42
Total	$ 238.69	$176.05	$146.32	$394.66
Percent of spoilage	13	16	17	17
Tons feedable silage	151	81	86	232
Annual cost per ton	$ 1.58	$ 2.17	$ 1.70	$ 1.70

*One earth floor, wood sides; one blacktop floor, wood sides; one concrete floor and one wood side, one earth side.

ANNUAL COSTS

Annual use cost of bunker silos varied with type of materials used in construction. Concrete floor, concrete block side silos had the highest annual cost per ton of feedable silage ($2.20). Some of these were of the box type (3 perpendicular concrete block walls with the fourth of wood, usually filled with a blower and the packing tractor removed on a truck after filling was completed). This box type construction was an intermediate step in the development of the bunker as now used.

The 17 concrete floor, wood side silos had the lowest cost at $1.58 per ton. These men reported a smaller percentage of spoilage, 13 percent, and enjoyed some of the advantages of a larger scale. This smaller percentage of spoilage was because of: (1) better filling, packing and topping off, (2) better drainage and (3) better removal, reducing deterioration.

All costs other than spoilage were lower than for upright silos. Smaller investment and a long reported life kept depreciation low. Small investment held other costs down, such as interest, insurance and taxes. Gravel floor, wood side silos had a small investment cost of $116 and low annual costs but a high spoilage cost of $125 per year. Thus, despite the low original investment required, their annual costs were higher than for better built silo structures.

TRENCH SILOS

Trench silos were constructed by making a rectangular excavation in a hillside or bank. Many trenches were in use before the development of the bunker type. Silage was dumped from a wagon or truck and packed with a tractor driven back and forth as filling progressed. Many farmers thought the hire of a bulldozer for excavation would be the only cost. Earth sides and floors were found to be unsatisfactory as men and equipment or livestock had to move in and around the silo, especially during wet weather and periods of thawing. It was soon found that an improved floor and approaches were necessary.

Improvements in the form of a solid floor were found in two-thirds of the trench silos. Of these, one-half were concrete and the remainder, gravel, blacktop or wood.

Improved sides were a final step in the evolution. Concrete, concrete block and wood were commonly used to line the side of the trench silos. Often the evolution of the unimproved ditch to a silo with a solid floor and lined sides extended over several years. Investments increased as floor and walls were improved. Extending these construction costs over several years had some advantage in that capital outlay required at one time was low.

INVESTMENT COSTS

Excavation costs were similar regardless of how the trench was finished. The type of materials used for the floor and sides of the trench controlled its cost per ton of capacity. Concrete floors at 20 cents per square foot had the highest cost but were preferred by farmers for their longer life and durability. Blacktop floors were used in 2 silos at a cost of 13 cents per square foot. Gravel floors at about 3 cents had a much lower cost and were considered fairly satisfactory when good drainage existed. Twenty-seven of the 34 trench silos did not have improved sides. Concrete block walls average 45 cents per square foot, which was almost twice that for wood and 2½ times that of concrete. Side improvements were desirable but not as vital for satisfactory use as solid floors. Repair or maintenance cost was primarily for wall maintenance in silos having earth sides.

Typically the trenches were higher, narrower and longer than bunkers. The depth of silage averaged 7.5 feet. Widths were universally greater at the top than at the bottom. Average width of trench

Trench silos can be constructed with a minimum of expense. Earth floors present problems when men, equipment or animals have to work in them under adverse weather conditions.

silos ranged from 9 to 35 feet with a mean of 16 feet. Top width of these silos averaged 18 feet and the bottom, 14 feet. Length of these silos was typically 100 feet, ranging from 40 to 140 feet.

Cost per ton of storage capacity was lower for larger silos than for smaller ones. However, since the construction costs were considerably less than for other types of silos, costs did not decrease as much with increases in capacity.

ANNUAL COSTS

Trench silo users experienced lower annual storage costs than for other types. Spoilage was the major item of cost although this was less than for bunkers because of the greater depth. The blanket of spoilage was about the same thickness but comprised a smaller part of the total volume. Obsolescence was a major source of depreciation but some reduction in satisfactory performance occurred because of deterioration of floors and sidewalls. Considerable variation was reported in the life of the trench silos included. Years of expected life as reported by farmers were used. Horizontal silos were a recent innovation, thus experience was limited. It is possible that many of these horizontal silos will not last as many years as reported. Some of the annual cost would be higher if shorter periods of use were realized.

TABLE 6.—Investment Costs of Trench Silos with Concrete Floor, Earth Sides by Three Sizes, Ohio, 1956

Items	Size		
	Small	Medium	Large
Height (feet)	7 5	7 5	7 5
Width (feet)	16	16	16
Length (feet)	54	102	149
Cost			
Excavation	$ 65	$122	$179
Floor	153	290	423
Total	$218	$412	$602
Tons of feedable silage	88	176	264
Cost per ton feedable silage*	$ 2.48	$ 2.34	$ 2.28

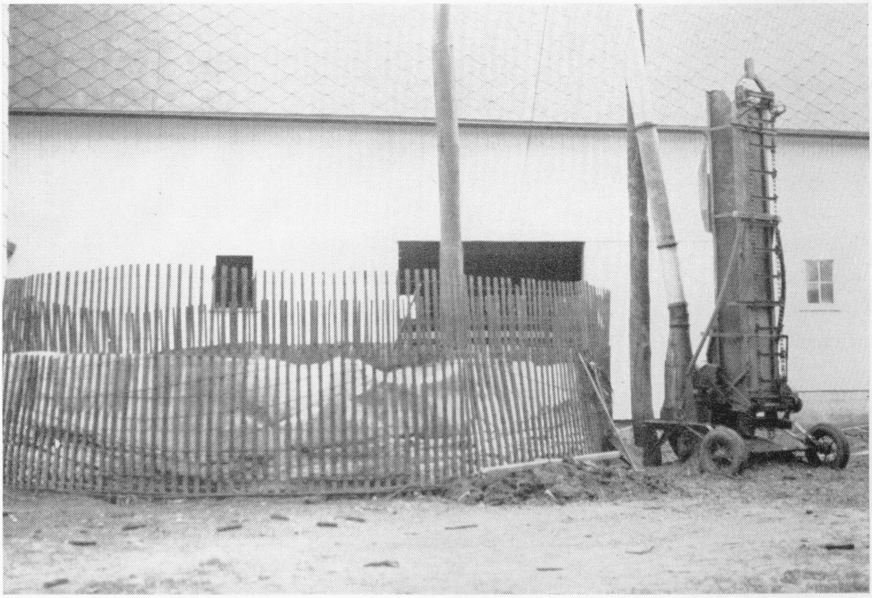
*Twelve percent loss.

Generally repairs consisted of cleaning the silo and approaches and re-forming the walls. Taxes and interest were based on construction costs. Spoilage was based on the tonnage that was lost or was reported unfeedable by the farmer.

STACK AND TEMPORARY SILOS

Information was obtained on only 9 stack and 8 temporary silos despite special effort to locate more. Wide variations in capacity, cost and spoilage losses limit the usefulness of this information.

None of the farmers using stacks reported any cash outlay. Silage was piled on the ground in a mound varying from 4 to 12 feet in height without any retaining sides. The stacks were rectangular with tapered sides and sloping ends. Spoilage losses experienced were high and labor used in removing the decomposed layer was great. All of the farmers using stacks had ample forages available for livestock needs. Several stacks were "self-fed" by using an electrified wire to restrict the livestock. Most important in the use of a stack was the establishment of a good seal and keeping the feeding face clean and free of contamination when self-feeding.



Picket fences are often used in temporary silos of this type. They require little if any cash outlay but losses from spoilage run high and limit the usefulness of this operation.

TABLE 7.—Annual Storage Costs by Type, 34 Trench Silos, Ohio, 1956
(Average Feedable Capacity)

Item	Type			
	Earth floor, earth sides	Concrete floor, earth sides	Other*	All types
Number	13	7	14	34
Investment	$139	$421	$411	$309
Years of life	44	39	32	38
Annual costs				
Depreciation	$ 3.15	$ 10.79	$ 12.84	$ 8.12
Repairs	8.61	4.29	6.57	6.88
Interest and taxes	4.02	12.20	11.89	8.95
Spoilage	112.01	176.38	122.74	139.35
Total	$127.79	$203.66	$154.04	$163.30
Tons feedable silage	137	222	124	156
Annual cost per ton	$ .93	$ .92	$ 1.24	$ 1.05

*Includes gravel, blacktop and wood floors and concrete block and wood sides.

The 8 temporary silos averaged 65 tons capacity and ranged from 30 to 125 tons. Seven farmers used picket or snow fence and one man used wire fencing to form the supporting walls. Sisalcraft paper was used to line these sides. Storage costs averaged $2.05 per ton of which $1.59 was for spoilage. Three men report negligible spoilage losses as they started to feed immediately after the silos were filled. Men delaying opening the silos and allowing the silage to make, experienced a storage cost of $2.38 per ton. Construction cost, including materials and labor, averaged $1.11 per ton.

HARVESTING PRACTICES

Mixtures. Alfalfa was used in the grass-legume mixture by all but four farmers. The other components of the mixture varied, but bromegrass, timothy and red clover were most common.

Maturity. Farmers tended to harvest these forages in early to medium maturity. Two-fifths of these men harvested during the early bloom stage, one-third at medium bloom and one-fourth at full bloom.

Conditioners were used by one-fourth of the farmers. The use of conditioners was employed by farmers with horizontal silos as frequently as those with upright structures. Sodium meta-bisulphite was used most frequently but molasses, corn, corn cobs and molasses, and corn and cob meal were also reported.

Wilting before chopping was practiced by men using windrow pickup harvesters or on one-half of the farms. Horizontal silo users tended to wilt an average of 1¾ hours while upright users wilted 2¾ hours.

Length of cut averaged ½ inch for upright silos and 1¼ inches for horizontal. Average length of cut was reported as one inch. A few upright owners reported less blower difficulty with the shorter length of cut.

Refilling with corn later in the season was only used by upright owners. This practice maximized the silo use and reduced fixed storage cost per ton.

EQUIPMENT AND POWER

The blower or an elevator was the major equipment difference between upright and horizontal silos. Field and transportation equipment were similar for all types of silos. Upright silos required a blower or elevator with a tractor for power; while horizontals required a tractor for packing.

Elevators were used by one-sixth of the upright owners. Most situations were not adapted to using an elevator. Less power and fewer clogging delays were advantages cited for the use of an elevator.

About as many direct cut as windrow pickup choppers were used. Three-fourths of the choppers were power takeoff powered; the other one-fourth had auxiliary engines.

TABLE 8.—Tractors Used to Harvest and Store Silage, 104 farms, Ohio, 1955

Tractors per farm	Percent
2	12
3	45
4	31
5	9
6	3

Half of the farmers use 2 wagons, 2 out of 5 used 3 wagons and one man in 10 used trucks. Four of every 10 farmers pulled a side delivery rake while mowing, thus requiring less labor and fewer power units than when these operations were performed separately. One farmer in five used a windrower and reported satisfactory operation in light stands but clogging difficulties were experienced in very heavy stands.

Three tractors were most commonly used with about 1/3 of the farmers using 4 tractors.

Three of every 5 farmers used 2-plow tractors; the others used larger tractors. Only 4 bulldozers and 2, 5-plow tractors were found on the 104 farms.

Most labor crews consisted of three or four men with a few farmers filling silos with two men and others using as many as six men. The regular farm labor force comprised 65 percent of the total, with 20 percent hired and 15 percent exchange or trade labor.

Typical Power, Labor and Equipment Combination for Harvesting and Storing Grass-Legume Silage, Ohio, 1956

Windrow choppers
- Mower, 7-foot
- Side delivery rake
- PTO windrow pickup chopper
- 2 wagons with unloaders
- 3 tractors (1, 3-plow and 2, 2-plow)
- 4 men (2 regular and 2 hired or exchange)
- 1 blower (for upright silos)

Direct cut choppers
- PTO direct cut chopper
- 2 wagons with unloaders
- 3 tractors (1, 3-plow and 2, 2-plow)
- 4 men (3 regular and 1 hired or exchange)
- 1 blower (for upright silos)

FARMERS' OPINIONS AND EXPERIENCES WITH GRASS-LEGUME SILAGE

1. Farmers reported that the reduction of weather risk was their most important reason for using grass-legume silage.
2. High quality feed, less labor and moderate harvesting and storage costs were also cited.
3. Most dairy farm operators liked grass-legume silage as well as corn silage but cattle feeders preferred corn silage.

4. About ¾ of the farmers expressed the view that grass-legume silage was a higher quality feed than hay. Those farmers said forage crop could be more easily harvested at a desired maturity with less of the nutrients lost from weather damage than when harvested as hay.
5. Increased milk production, less storage space, and saving of high cost concentrate ration were given as reasons for liking grass silage by several farmers.
6. Major objections included the very large labor, power and equipment requirements for the harvesting and filling operation.
7. Very unpleasant odors were sometimes encountered causing some farmers to dislike grass-legume silage.
8. High spoilage losses, particularly in horizontal silos, were a disadvantage on farms with limited forage supplies.

APPENDIX

TABLE I.—Investment and Annual Costs per Ton of Feedable Silage in Upright, Bunker and Trench Silos, Ohio, 1956

Costs	Tons feedable silage				
	50	100	200	300	350
Upright (concrete stave)					
Investment	$37.56	$25.56	$19.16	$15.94	$15.13
Annual	2.50	1.73	1.29	1.09	1.04
Bunker (concrete floor, creosote wood sides)					
Investment	15.40	8.85	7.18	5.75	5.72
Annual	2.00	1.56	1.43	1.31	1.26
Trench (concrete floor, earth sides)					
Investment	2.72	2.29	2.20	2.14	2.09
Annual	1.30	1.21	1.16	1.11	1.06

TABLE II.—Capacity of 67 Upright Silos, Grass-Legume Silage, Ohio, 1956

Type	Number	Typical size	Tons capacity			
			Total	Settled	Spoiled	Feed
Concrete stave	36	12 X 40	89	75	3 0	72
Metal	14	12 X 30	72	61	2 7	58
Wood	9	12 X 30	76	65	2 4	63
Other	8	------*	92	78	3 1	75
All	67	------	84	71	2 9	68

*Four tile, 14 X 40 4 concrete block, 10 X 34

TABLE III.—Size and Type of 67 Upright Silos, Ohio, 1956

Tons of feedable capacity	Average tons	Type			
		Concrete stave	Metal	Wood	Other*
31 65	48	18	9	5	4
66 100	83	11	4	3	2
101 135	118	6	1	1	1
136 170	153	1	--	--	1
Total	----	36	14	9	8

*Four tile 4 concrete block

TABLE IV.—Capacity of 32 Bunker Silos, Ohio, 1956

Measure	Number	Capacity		
		Average	Typical	Typical range
Height (feet)	32	6 4	6	6–7
Width (feet)	30*	20 7	24	15–25
Length (feet)	32	75	60	50–96
Tons				
Settled	32	155 6	119	68–206
Feedable silage	32	133 1	93	51–182
Percent spoiled				
Covered	16	13 1	11	4–22
Uncovered	14	18 2	14	8–27

*Two silos had slanted sides—20 feet at top 15 feet at bottom

TABLE V.—Size and Capacity of 32 Bunker Silos by Materials, Ohio, 1955-1956

Material	Number	Feet			Tons		
		Height	Width	Length	Settled	Spoiled	Fed
Concrete floor wood sides	17	6	22	79	173	22	151
Concrete floor, concrete block sides	6	7	16	56	97	16	81
Gravel floor, wood sides	6	6	18	68	103	17	86
Other*	3	7	24	105	279	47	232

*One earth floor wood sides one blacktop floor wood sides one concrete floor, one wood and one earth side

TABLE VI.—Floor and Side Construction Cost, 32 Bunker Silos, Ohio, 1956

Material	Number	Square feet	Cost	
			Total	Per square foot
Floor				
Concrete	24	1675	$434	$ .26
Gravel	6	1212	67	.06
Blacktop	1	4760	675	.14
Earth	1	1200	----	----
Side				
Wood	25	970	$596	$ .61
Concrete block	6	808	700	.87
Wood and earth	1	1280	278	.22

TABLE VII.—Excavation, Floor and Side Construction Cost, 34 Trench Silos, Ohio, 1956

Item	Number	Feet	Cost	
			Total	Per foot
Excavation	34	12426 cu ft	$121	$ .010
Floor				
Earth	13	1140 sq. ft.	----	------
Concrete	13	1616 sq ft	263	.203
Gravel	5	1308 sq. ft.	37	.028
Blacktop	2	2020 sq. ft.	258	.128
Wood	1	1000 sq. ft.	16	.016
Sides				
Earth	25	1488 sq. ft	----	------
Concrete	3	1208 sq. ft.	208	.172
Concrete block	3	881 sq. ft.	439	.447
Wood	2	2080 sq. ft.	480	.231
Wood and earth	1	1840 sq. ft.	54	.029